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PESTICIDES IN SURFACE WATERS OF THE UNITED STATES. A FIVE-YEAR SUMMARY. 1964-1968

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Federal Water Pollution Control Administration
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U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
DIVISION OF WATER QUALITY RESEARCH
ANALYTICAL QUALITY CONTROL LABORATORY
CINCINNATI, OHIO

SEPTEMBER 1969

ABSTRACT

This report summarizes the results of five annual synoptic surveys (1964 through 1968) for chlorinated hydrocarbon pesticides in surface waters of the United States. The results showed widespread occurrence of these compounds. The number of occurrences reached a peak in 1966 and then declined sharply in 1967 and 1968. Dieldrin and DDT and its congeners DDE and DDD were the compounds most frequently detected throughout the five-year period. The maximum concentrations found have not exceeded permissible limits as they relate to human intake directly from a domestic water supply. However, they have often exceeded the environmental limit of 0.050 µg/l recommended by the Federal Committee on Water Quality Criteria.

PESTICIDES IN SURFACE WATERS OF THE UNITED STATES

A FIVE-YEAR SUMMARY

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Since September 1964, the Federal Water Pollution Control Administration has conducted annual synoptic surveys for chlorinated hydrocarbon pesticides in surface waters (1,2,3). In September, 1967 the fourth such survey was conducted and in June, 1968 the first spring survey was made. This surveillance activity has been a part of a continuing program for determining refractory organic substances in surface waters. The purpose is to provide information on present levels and trends of pesticides in waters to permit pollution control authorities to assess the degree of hazard and, if necessary, to provide the required control.

Through 1967 the surveys were conducted in September when streamflows are minimal. The 1968 survey was conducted in June, in an effort to get comparative data during run-off period after pesticide application.

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Previous reports (2,3) have compared synoptic grab sample data with data obtained by the carbon adsorption method (CAM). Generally good agreement was noted between the two types of samples and no further comparisons are reported here.

Samples were collected through the cooperative efforts of Federal, State, local and private agencies at approximately 100 sampling stations. These stations are located mainly on interstate and international boundary waters at sites ranging from water treatment plant intakes to near mouths of rivers as they discharge to tidal waters.

This report summarizes the data obtained throughout the five surveys with emphasis on the 1967 and 1968 surveys. The number of samples analyzed for these surveys were 110 and 114, respectively. A total of 529 samples were analyzed for the five surveys.

METHODS

The basic procedures for determination of eleven chlorinated hydrocarbon pesticides are detailed in U.S. Department of the Interior Publication WP-22 (4) and in the "FWPCA Method for Chlorinated Hydrocarbon Pesticides in Water and Wastewater"(5). Briefly, the samples were collected in 1-quart glass bottles equipped with screw caps fitted with teflon liners. The samples were subjected to liquid-liquid extraction with 15% ethyl ether in hexane and then to preliminary clean-up and separation by thin-layer chromatography. Recoveries ranged from 65 to 97% for the chlorinated pesticides determined. Although the method was not specifically designed for the analysis of organophosphorus compounds,

recoveries for the compounds listed below ranged from 40 to 75%. Qualitative and quantitative determination was accomplished by subjecting the extracts to electron capture and flame photometric gas chromatography using two different columns.

The methods are specific for dieldrin, endrin, DDT, DDE, DDD, aldrin, heptachlor, heptachlor epoxide, lindane, BHC, γ-chlordane and technical chlordane. In addition, the use of the flame photometric detector provided specificity for many organophosphorus pesticides. For the 1967 and 1968 surveys, samples were also analyzed for methyl parathion, parathion, fenthion, ethion, malathion and trithion.

The practical lower limit of detectability for the chlorinated pesticides is 0.001 to 0.002 µg/l, except for technical chlordane which has a limit of 0.005 µg/l. Toxaphene can be detected if it is present at levels of the order of 1 µg/l. The detection limits for the phosphorus compounds are 0.010 to 0.025 µg/l. All results are reported without correction for recovery efficiencies. Thus, the reported concentrations represent minimum values, the actual value being equal to or greater than the reported value.

RESULTS AND DISCUSSIONS

The results of the 1967 and 1968 surveys are listed in Tables 1 and 2. Table 3 lists the total number of samples and positive pesticide occurrences for each of the five surveys. The data show that the total occurrences peaked in 1966 and fell off significantly in 1967 and 1968. Figure 1 summarizes the percent occurrences of eleven pesticides for the five surveys. It shows that the occurrences decreased sharply

after 1966 for all pesticides, except BHC which showed only a slight decline. It also shows that the 1966 peak in total occurrences is largely due to the increase in DDD occurrences. The spring survey showed a slight increase in dieldrin and DDT.

Table 4 summarizes the occurrences by FWPCA region and Figure 2 shows the geographical occurrence of dieldrin, the DDT group, and BHC. In 1966, the number of occurrences peaked in the South Central Region and in all regions East of the Mississippi. The Missouri Basin Region showed a gradual decline from 1964 to 1966, then a very sharp drop in 1967 and 1968. In the Southwest and Northwest Regions the occurrences fluctuated from 1964 to 1966 and then fell off to virtually nothing in 1967 and 1968. Throughout the five surveys dieldrin dominated the pesticide occurrences in all regions and in total occurrences with 199 positive results. DDT was second in overall occurrences with 86. DDT and its congeners DDE and DDD as a group accounted for 183 occurrences. Aldrin and chlordane were low with just two and five occurrences, respectively. Consistent geographical relationships among the various pesticides are difficult to identify, however, the overall occurrences show that dieldrin slightly predominated in all regions East of the Mississippi and the DDT group, considered as one, predominated in regions West of the Mississippi.

Since 1966, BHC has been detected in 10 of 12 samples from the main stem of the Ohio River. This consistent occurrence was verified by the results of the analyses of monthly CAM samples performed in this laboratory. The synoptic surveys and additional investigations

by this laboratory produced only one positive result for BHC in eight major tributaries to the Ohio. That one was at Pittsburgh on the Allegheny River in September 1966. Twenty-three other BHC occurrences were widely scattered throughout the country.

The reduction of endrin occurrences from nearly 50% in 1964 to zero in 1968 is particularly significant in light of its association with major fish kills in the Lower Mississippi prior to 1964.

Heptachlor was found in 14% of the samples in 1965 and in less than one percent thereafter. Heptachlor epoxide was found in approximately 14% of the samples in 1965 and 1966 and dropped to zero thereafter.

The ten locations at which the highest levels of each pesticide were observed for each survey are listed in Table 5. Individual locations varied considerably. However, two stations on the Savannah River, North Augusta, S.C. and Port Wentworth, Ga., were in the top ten dieldrin occurrences for all five surveys. Other rivers and locations that were consistently in the top ten are the Merrimack, Schuylkill, Connecticut, Delaware, Potomac, Lower Ohio, Lower Mississippi, Missouri (at Kansas City), Rio Grande, and Red River (North).

The highest level of each pesticide found is listed in Table 6 along with water quality criteria for public water supplies and farmstead uses (6) and suggested maximum reasonable stream allowance (7). While the maximum concentrations have not exceeded permissible limits as they relate to human intake directly from a domestic water supply, they have in some cases exceeded or come quite close to the maximum reasonable allowance suggested by Ettinger and Mount (7). Because of the biological concentration factor, these levels are considered hazardous in waters from which fish

are harvested for human consumption. In addition, because of their toxicity to fish, the Federal Committee on Water Quality Criteria recommends that environmental levels of these substances not be permitted to rise above 0.050 µg/l (6).

Of the 84 stations where samples were collected in all five surveys, twelve had at least one positive occurrence in each survey. These are listed in Table 7. All but one of these are East of the Mississippi River. In addition, sixteen widely spread locations had at least one positive occurrence in four of the five surveys.

Since pesticides are so common in surface waters, it is of interest to note those locations at which they are absent or occur infrequently. Table 8 lists the Stations that fall in this category. Locations in the West and Northwest dominate this group.

Spring run-off after pesticide application was expected to cause an increase in the number of occurrences and in concentration levels in agricultural areas. Such an increase was not evident from the data obtained. This may be, in part, due to the wet spring experienced in much of the country in 1968 which delayed planting and subsequent pesticide application in many areas. As a result, our collection period may have been too early to catch an increased pesticide load.

SUMMARY AND CONCLUSIONS

The occurrences of chlorinated hydrocarbon pesticides continue to be widespread. However, after reaching a peak in 1966, the total number of occurrences throughout the country dropped sharply

in 1967 and 1968. This trend is consistent with production and usage reports of the U.S. Department of Agriculture (8) and the U.S. Department of the Interior (9) which show a trend toward decreased use of the persistent chlorinated hydrocarbon compounds and an increase in the use of organophosphorus and carbamate compounds. The absence of a corresponding increase in the occurrences of organophosphates may be due to their relatively rapid hydrolysis rate in water and the method of analysis which was not designed specifically for this class of compounds.

The data reported here and the grab sample and CAM sample data reported earlier (1,2,3) represent pesticide levels and trends in the major interstate waterways sampled. They do not, necessarily, reflect the conditions existing in all sub-basins or areas of heavy pesticide use, such as irrigation districts. For example, in extensive surveillance operations conducted by FWPCA in the Lower Colorado River area, during the summers of 1967 and 1968, the occurrences were frequent and the levels generally higher for both chlorinated and organophosphorus pesticides (10).

Dieldrin continued to dominate the pesticide occurrences, although the total number of occurrences had dropped significantly.

BHC has been found consistently in the main stem of the Ohio River since 1966. The source or sources of this material have not yet been determined.

The pesticide concentrations found were 1/10 to 1/500 of the permissible levels for water supplies given in Water Quality Criteria (6). However, in some instances the concentrations found have exceeded the suggested maximum reasonable stream allowance (7), as well as the environmental limit recommended by the Committee on Water Quality Criteria (6).

Future surveys should be conducted to determine if the decreasing trend of chlorinated hydrocarbon pesticides occurrences is continuing. The methods of analysis should include procedures specifically designed to determine organophosphorus compounds. A greatly expanded sampling program would be necessary to determine seasonal variations in pesticide occurrences. This could best be done on a regional basis.

ACKNOWLEDGEMENT

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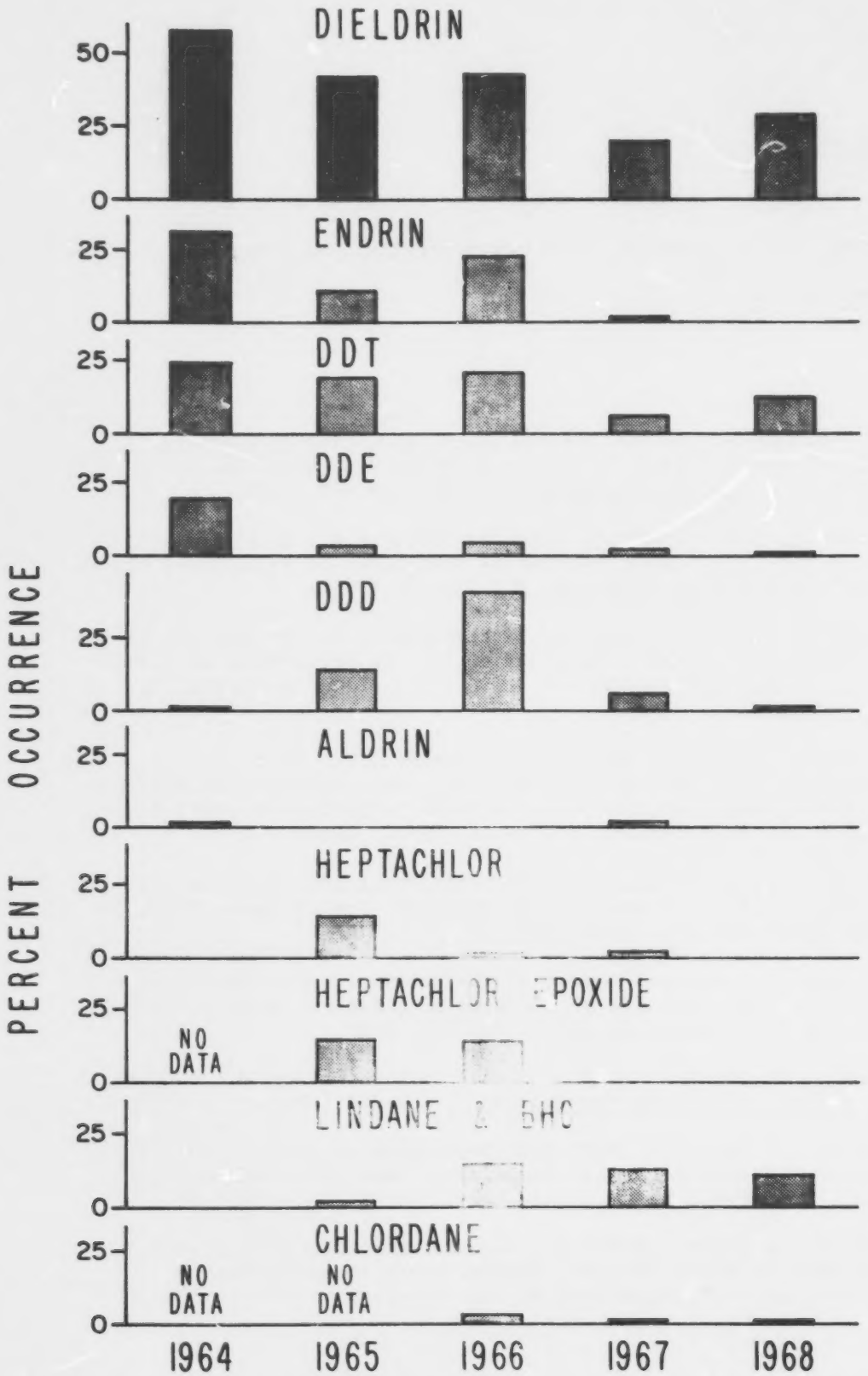
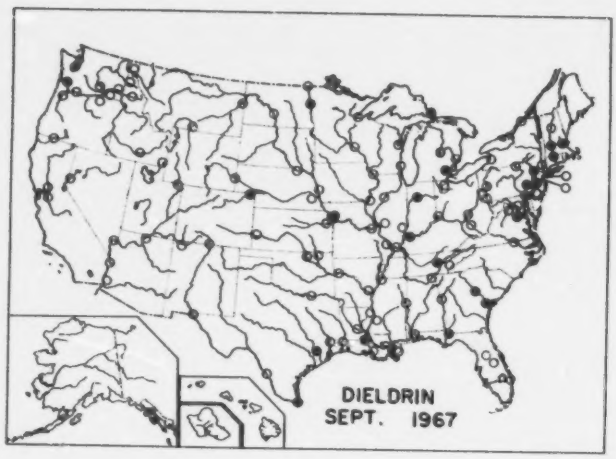
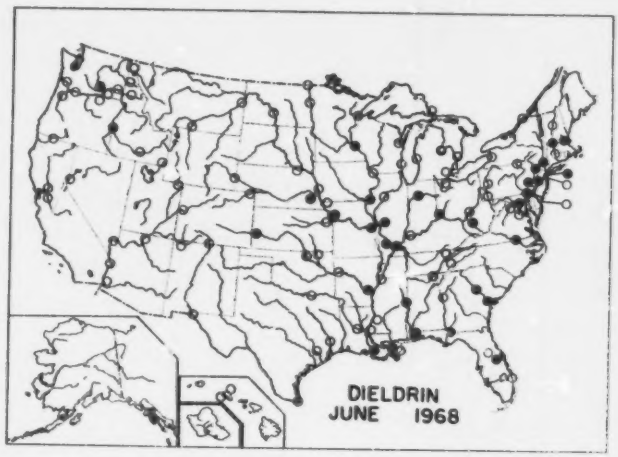
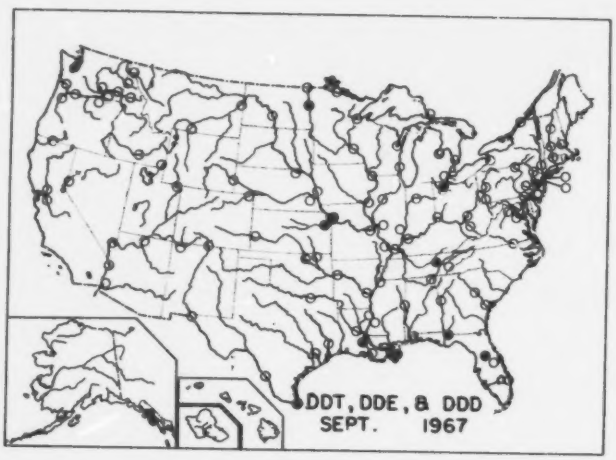
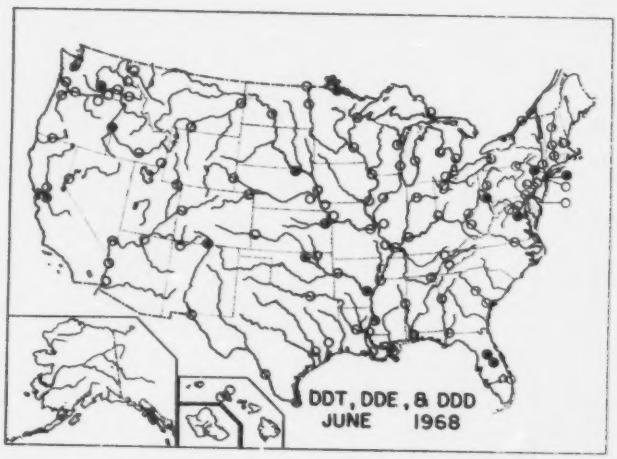


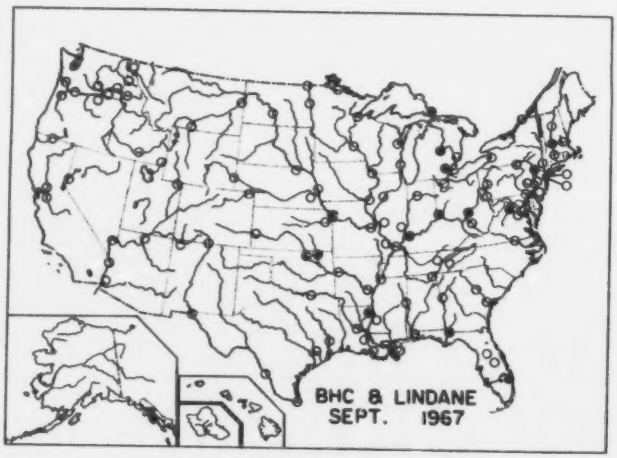
FIGURE 1. PERCENT OCCURRENCE OF TEN CHLORINATED HYDROCARBON PESTICIDES, 1964 – 1968.











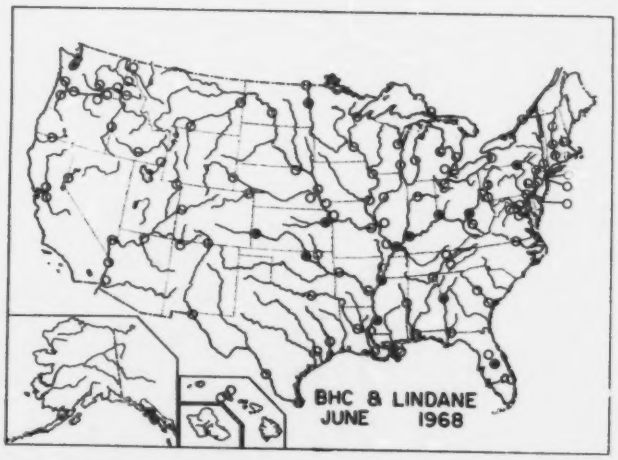


FIGURE 2. OCCURRENCE OF CHLORINATED HYDROCARBON PESTICIDES IN SURFACE WATERS, SYNOPTIC SURVEYS OF 1967 AND 1968. (● - PRESENT; ○ - ABSENT).

TABLE 1 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Northeast Region							
Connecticut River:							
Enfield Dam, Conn.	.005	--	--	--	--	--	--
Northfield, Mass.	.017	--	--	--	--	.002	--
Wilder, Vt.	--	--	--	--	--	--	--
Schuylkill River:							
Philadelphia, Pa.	.044	--	--	--	--	--	--
Hudson River:							
Poughkeepsie, N. Y.	--	--	--	--	--	--	--
Narrows, N. Y.	--	--	--	--	--	--	--
Merrimack River:							
Lowell, Mass.	.066	--	--	--	--	--	--
Delaware River:							
Trenton, N. J.	.010	--	.017	--	.036	--	--
Martins Creek, Pa.	.013	--	--	--	--	.002	--
Raritan River:							
Perth Amboy, N. J.	--	--	--	--	--	--	--
Delaware Bay: a	--	--	--	--	--	--	--
b	--	--	--	--	--	--	--
Middle Atlantic Region							
Potomac River:							
Great Falls, Md.	--	--	--	--	--	--	--
Washington, D. C.	.025	--	--	--	--	--	--
Shenandoah River:							
Berryville, Va.	--	--	--	--	--	--	.002
Susquehanna River:							
Conowingo, Md.	--	--	--	--	--	--	--
Sayre, Pa.	--	--	--	--	--	--	--
Roanoke River:							
John H. Kerr Dam, Va.	--	--	--	--	--	--	--

TABLE 1 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Middle Atlantic Region (cont'd)							
Neuse River:							
Raleigh, N. C.	--	--	--	--	--	--	--
Southeast Region							
Apalachicola River							
Chattahoochee, Fla.	.015	--	--	--	.053	.003	--
Beauclair River:							
Lake Apopka, Fla.	--	--	.316	.050	.231	--	--
Escambia River:							
Century, Fla.	--	--	--	--	--	--	--
Oklahawa River:							
Orlando, Fla.	--	--	--	--	--	--	--
W. Palm Beach Canal:							
W. Palm Beach, Fla.	--	--	--	--	--	.003	--
Chattahoochee River:							
Lanett, Ala.	--	--	--	--	--	P	--
Savannah River:							
Port Wentworth, Ga.	.039	--	--	--	--	--	--
North Augusta, S. C.	.087	--	--	--	--	--	--
Clinch River:							
Kingston, Tenn.	.004	--	--	--	.032	--	--
Tennessee River:							
Bridgeport, Ala.	--	--	--	--	--	--	--
Lenoir City, Tenn.	--	--	--	--	--	--	--
Tombigbee River:							
Columbus, Miss.	--	--	--	--	P	--	--
Ohio Basin Region							
Allegheny River:							
Pittsburgh, Pa.	--	--	--	--	--	--	--

TABLE 1 - RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Ohio Basin Region (cont'd)							
Kanawha River:							
Winfield Dam, W. Va.	--	--	--	--	--	P	--
Monongahela River:							
Pittsburgh, Pa.	--	--	--	--	--	--	--
Ohio River:							
Cairo, Ill.	--	--	--	--	--	--	--
Evansville, Ind.	.020	--	--	--	--	--	.008
Cincinnati, O.	--	--	--	--	--	--	.013
above Addison, O.	--	--	--	--	--	--	.006
Wabash River:							
Lafayette, Inc.	.009	--	--	--	--	--	--
New Harmony, Ind.	--	--	--	--	--	--	--
Great Lakes Region							
St. Lawrence River:							
Massena, N. Y.	--	--	--	--	--	--	P
Lake Erie:							
Buffalo, N. Y.	P	--	--	--	--	--	--
Detroit River:							
Detroit, Mich.	.014	--	--	--	--	--	.002
St. Clair River:							
Port Huron, Mich.	--	--	--	--	--	--	--
St. Mary's River:							
Sault Ste. Marie, Mich.	.004	--	--	--	--	.003	--
Saginaw River:							
Bay City, Mich.	P	--	--	--	--	--	.007
Lake Superior:							
Duluth, Minn.	--	--	--	--	--	--	--
Lake Michigan:							
Milwaukee, Wis.	--	--	--	--	--	--	--

TABLE 1 – RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Great Lakes Region (cont'd)							
Maumee River:							
Toledo, O.	--	.086	--	--	.270	--	--
Illinois River:							
Peoria, Ill.	--	--	--	--	--	--	--
Mississippi River:							
Cape Girardeau, Mo.	--	--	--	--	--	--	--
E. St. Louis, Ill.	--	--	--	--	--	--	--
Burlington, Iowa	--	--	--	--	--	--	--
Dubuque, Iowa	--	--	--	--	--	--	--
St. Paul, Minn.	--	--	--	--	--	--	--
Fox River:							
Green Bay, Wis.	--	--	--	--	--	--	--
Missouri Basin Region							
Missouri River:							
St. Louis, Mo.	--	--	--	--	--	--	--
Kansas City, Kan.	.012	--	.066	--	--	.010	--
Omaha, Neb.	--	--	--	--	--	--	--
Yankton, S. D.	--	--	--	--	--	--	--
Bismarck, N. D.	--	--	--	--	--	--	--
North Platte River:							
Henry, Neb.	--	--	--	--	--	--	--
Platte River:							
Plattsmouth, Neb.	--	--	--	--	--	--	--
South Platte River:							
Julesburg, Colo.	.024	--	--	--	--	--	--
Yellowstone River:							
Sidney, Mont.	--	--	--	--	--	--	--
Rainy River:							
Baudette, Minn.	--	--	--	--	--	--	--

TABLE 1 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Missouri Basin Region (cont'd)							
Red River (North)							
Grand Forks, N. D.	.087	--	.054	--	--	--	--
Emerson, Manitoba	P	--	--	--	--	--	--
Kansas River:							
Lawrence, Kan.	--	.133	--	--	.840	--	--
Big Horn River:							
Hardin, Mont.	--	--	--	--	--	--	--
South Central Region							
Atchafalaya River:							
Morgan City, La.	--	--	--	--	--	--	--
Arkansas River:							
Pendleton Ferry, Ark.	--	--	--	--	--	P	--
Fort Smith, Ark.	--	--	--	--	--	--	--
Ponca City, Okla.	--	--	--	--	--	--	--
Coolidge, Kan.	--	--	--	--	--	--	--
Brazos River:							
Arcola, Tex.	.024	--	--	--	P	--	--
Mississippi River:							
New Orleans, La.	--	--	.019	--	--	--	--
Vicksburg, Miss.	--	--	--	--	--	--	--
Delta, La.	--	--	--	--	--	.024	--
West Memphis, Ark.	--	--	--	--	--	--	--
New Roads, La.	.008	--	--	--	.015	--	--
Red River (South):							
Alexandria, La.	--	--	--	--	--	--	--
Denison, Tex.	--	--	--	--	--	--	--
Rio Grande River:							
Brownsville, Tex.	.002	--	.018	.022	--	--	--
El Paso, Tex.	--	--	--	--	--	--	--
Alamosa, Colo.	--	--	--	--	--	--	--

TABLE 1 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
South Central Region (cont'd)							
Verdigris River:							
Nowata, Okla.	--	--	--	--	--	.009	--
Trinity River:							
Houston, Tex.	--	--	--	--	--	--	--
Southwest Region							
Bear River:							
Preston, Id.	--	--	--	--	--	--	--
Colorado River:							
Yuma, Ariz.	--	--	--	--	--	--	--
Parker Dam, Calif.	--	--	--	--	--	--	--
Boulder City, Nev.	--	--	--	--	--	--	--
Page, Ariz.	--	--	--	--	--	--	--
Green River:							
Dutch John, Utah	--	--	--	--	--	--	--
Klamath River:							
Keno, Ore.	--	--	--	--	--	--	--
Sacramento River:							
Greens Landing, Calif.	--	--	--	--	--	--	--
San Joaquin River:							
Vernalis, Calif.	--	--	--	--	--	--	--
San Juan River:							
Shiprock, N. Mex.	--	--	--	--	--	--	--
Truckee River:							
Farad, Calif.	--	--	--	--	--	--	--
Northwest Region							
Clearwater River:							
Lewiston, Id.	--	--	--	--	--	--	--

TABLE 1 – RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, SEPTEMBER 1967
(continued)

Location	Concentration in micrograms per liter(1)						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Northwest Region (cont'd)							
Columbia River:							
Clatskanie, Ore.	.018	--	--	--	--	--	--
Bonneville Dam, Ore.	--	--	--	--	--	--	--
McNary Dam, Ore.	--	--	--	--	--	--	--
Pasco, Wash.	--	--	--	--	--	--	--
Pend Oreille River:							
Albeni Falls, Id.	--	--	--	--	--	--	--
Snake River:							
Wawawai, Wash.	--	--	--	--	--	--	--
American Falls, Id.	--	--	--	--	--	--	--
Spokane River:							
Post Falls, Id.	--	--	--	--	--	--	--
Willamette River:							
Portland, Ore.	--	--	--	--	--	--	--
Yakima River:							
Richland, Wash.	--	--	--	--	--	--	--

(1)-The Lanett, Ala. sample contained .036 µg/l of Chlordane (tech). The Nowata, Okla. sample contained .002 µg/l of aldrin and .003 µg/l of heptachlor. The Wawawai, Wash. sample contained .050 µg/l of parathion and .380 µg/l of ethion. All other samples gave negative results for aldrin, heptachlor, heptachlor epoxide, parathion, methyl parathion, fenthion, ethion, malathion and trithion.

(--)-Indicates none detected.

(P)-Indicates presumptive. Data are reported as presumptive in instances where the results of chromatography were highly indicative but did not meet all requirements for positive identification and quantification.

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Northeast Region							
Connecticut River:							
Enfield Dam, Conn.	--	--	--	--	--	--	--
Northfield, Mass.	.022	--	--	--	--	--	--
Wilder, Vt.	--	--	--	--	--	--	--
Schuylkill River:							
Philadelphia, Pa.	.027	--	--	--	--	--	--
Hudson River:							
Poughkeepsie, N. Y.	.013	--	--	--	--	--	--
Narrows, N. Y.	.004	--	.030	--	--	--	--
Merrimack River:							
Lowell, Mass.	.012	--	--	--	--	--	--
Delaware River:							
Trenton, N. J.	.007	--	--	--	--	--	--
Martins Creek, Pa.	.007	--	.015	--	--	--	--
Raritan River:							
Perth Amboy, N. J.	--	--	--	--	--	--	--
Delaware Bay:	--	--	--	--	--	--	--
Middle Atlantic Region							
Potomac River:							
Great Falls, Md.	.007	--	--	--	--	--	--
Washington, D. C.	--	--	.033	--	--	--	--
Shenandoah River:							
Berryville, Va.	--	--	--	--	--	--	--
Susquehanna River:							
Conowingo, Md.	.007	--	--	--	--	--	--
Sayre, Pa.	--	--	--	--	--	--	.009
Roanoke River:							
John H. Kerr Dam, Va.	.010	--	--	--	--	--	--
Neuse River:							
Raleigh, N. C.	--	--	--	--	--	--	--

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Southeast Region							
Apalachicola River:							
Chattahoochee, Fla.	.027	--	--	--	--	--	--
Beauclair River:							
Lake Apopka, Fla.	--	--	.220	.041	.156	--	--
Escambia River:							
Century, Fla.	.006	--	--	--	--	--	--
Oklahawa River:							
Orlando, Fla.	.004	--	.005	--	--	--	.015
W. Palm Beach Canal:							
West Palm Beach, Fla.	--	--	--	--	--	--	--
Chattahoochee River:							
Lanett, Ala.	--	--	--	--	--	--	.025
Savannah River:							
Port Wentworth, Ga.	.039	--	--	--	--	--	--
North Augusta, S. C.	.059	--	--	--	--	--	--
Tennessee River:							
Bridgeport, Ala.	--	--	--	--	--	--	--
Lenoir City, Tenn.	--	--	--	--	--	--	--
Oak Ridge, Tenn.	--	--	--	--	--	--	--
Tombigbee River:							
Columbus, Miss.	.407	--	--	--	--	--	--
Ohio Basin Region							
Allegheny River:							
Pittsburgh, Pa.	--	--	--	--	--	--	--
Kanawha River:							
Winfield, W. Va.	.154	--	--	--	--	--	--
Monongahela River:							
Pittsburgh, Pa.	--	--	.051	--	--	--	--

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Ohio Basin Region (cont'd)							
Ohio River:							
Cairo, Ill.	.005	--	--	--	--	--	.020
Evansville, Ind.	--	--	--	--	--	--	.055
Cincinnati, O.	.014	--	--	--	--	--	.028
above Addison, O.	--	--	--	--	--	--	.112
Wabash River:							
Lafayette, Ind.	.005	--	--	--	--	--	--
Great Lakes Region							
St. Lawrence River:							
Massena, N. Y.	--	--	--	--	--	--	--
Lake Erie:							
Buffalo, N. Y.	--	--	--	--	--	--	--
Detroit River:							
Detroit, Mich.	--	--	--	--	--	--	--
Grand River:							
at Grand Haven, Mich.	--	--	--	--	--	--	--
St. Clair River:							
Port Huron, Mich.	--	--	--	--	--	--	--
St. Mary's River:							
Sault Ste. Marie, Mich.	--	--	--	--	--	--	--
Saginaw River:							
Bay City, Mich.	--	--	--	--	--	--	--
Lake Superior:							
Duluth, Minn.	--	--	--	--	--	--	--
Lake Michigan:							
Milwaukee, Wis.	--	--	--	--	--	--	--
Maumee River:							
Toledo, O.	--	--	--	--	--	--	--

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Great Lakes Region (cont'd)							
Illinois River:							
Peoria, Ill.	--	--	--	--	--	--	--
Mississippi River:							
Cape Girardeau, Mo.	.014	--	--	--	--	--	--
E. St. Louis, Ill.	.011	--	--	--	--	--	--
Burlington, Iowa	.010	--	--	--	--	--	--
Dubuque, Iowa	--	--	--	--	--	--	--
St. Paul, Minn.	.011	--	--	--	--	--	--
Fox River:							
Green Bay, Wis.	--	--	--	--	--	--	--
Missouri Basin Region							
Missouri River:							
St. Louis, Mo.	.010	--	--	--	--	--	--
Kansas City, Kan.	.009	--	--	--	--	--	--
Omaha, Neb.	--	--	--	--	--	--	--
Yankton, S. D.	--	--	.053	--	--	--	--
Bismarck, N. D.	--	--	--	--	--	--	--
St. Joseph, Mo.	--	--	--	--	--	--	--
North Platte River:							
Henry, Neb.	--	--	--	--	--	--	--
Platte River:							
Plattsmouth, Neb.	.005	--	--	--	--	--	--
South Platte River:							
Julesburg, Colo.	--	--	--	--	--	--	--
Yellowstone River:							
Sidney, Mont.	--	--	--	--	--	--	--
Rainy River:							
Beaudette, Minn.	--	--	.037	--	--	--	--

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Missouri Basin Region (cont'd)							
Red River (North):							
Grand Forks, N. D.	--	--	--	--	--	--	.027
Emerson, Manitoba	--	--	--	--	--	--	--
Kansas River:							
Lawrence, Kan.	--	--	.008	--	--	.003	--
Big Horn River:							
Hardin, Mont.	--	--	--	--	--	--	--
South Central Region							
Atchafalaya River:							
Morgan City, La.	.005	--	--	--	--	--	--
Arkansas River:							
Pendleton Ferry, Ark.	.005	--	.037	--	--	--	--
Fort Smith, Ark.	--	--	--	--	--	--	--
Ponca City, Okla.	--	--	--	--	--	--	.013
Coolidge, Kan.	.009	--	--	--	--	--	.025
Brazos River:							
Arcola, Tex.	--	--	--	--	--	--	--
Mississippi River:							
New Orleans, La.	--	--	--	--	--	--	--
Vicksburg, Miss.	--	--	.109	--	--	.004	--
West Memphis, Ark.	--	--	--	--	--	--	.005
St. Francisville, La.	--	--	--	--	--	--	--
Red River (South):							
Alexandria, La.	--	--	--	--	--	--	--
Denison, Tex.	--	--	--	--	--	--	--
Rio Grande River:							
Brownsville, Tex.	--	--	--	--	--	--	--
El Paso, Tex.	--	--	--	--	--	--	--
Alamosa, Colo.	--	--	.029	--	--	--	--

TABLE 2 — RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
South Central Region (cont'd)							
Verdigris River:							
Nowata, Okla.	--	--	--	--	--	--	--
Trinity River:							
Houston, Tex.	--	--	--	--	--	--	--
Southwest Region							
Bear River:							
Preston, Id.	--	--	--	--	--	--	--
Colorado River:							
Yuma, Ariz.	--	--	--	--	--	--	--
Parker Dam, Calif.	--	--	--	--	--	--	--
Boulder City, Nev.	--	--	--	--	--	--	--
Page, Ariz.	--	--	--	--	--	--	--
Loma, Colo.	--	--	--	--	--	--	--
Green River:							
Dutch John, Utah	--	--	--	--	--	--	--
Klamath River:							
Keno, Ore.	--	--	--	--	--	--	--
Sacramento River:							
Green's Landing, Calif.	--	--	--	--	--	--	--
San Joaquin River:							
Vernalis, Calif.	--	--	.030	--	--	--	--
San Juan River:							
Shiprock, N. Mex.	--	--	--	--	--	--	--
Truckee River:							
Farad, Calif.	--	--	--	--	--	--	--
Kiikii Stream:							
Oahu, Hawaii	--	--	--	--	--	--	--
Waikele Stream:							
Oahu, Hawaii	--	--	--	--	--	--	--

TABLE 2 – RESULTS OF SYNOPTIC SURVEY FOR PESTICIDES IN SURFACE WATERS, JUNE 1968
(continued)

Location	Concentration in micrograms per liter[1]						
	Dieldrin	Endrin	DDT	DDE	DDD	Lindane	BHC
Northwest Region							
Clearwater River:							
Lewiston, Id.	--	--	--	--	--	--	--
Columbia River:							
Clatskanie, Ore.	--	--	--	--	--	--	--
Bonneville Dam, Ore.	--	--	--	--	--	--	--
McNary Dam, Ore.	--	--	--	--	--	--	--
Pasco, Wash.	--	--	--	--	--	--	--
Pend Oreille River:							
Albeni Falls, Id.	--	--	--	--	--	--	--
Snake River:							
Wawawai, Wash.	--	--	--	--	--	--	--
Payette, Id.	.004	--	.015	--	--	--	--
American Falls, Id.	--	--	--	--	--	--	--
Spokane River:							
Post Falls, Id.	--	--	--	--	--	--	--
Willamette River:							
Portland, Ore.	--	--	--	--	--	--	--
Yakima River:							
Richland, Wash.	.006	--	.017	--	--	--	--

(1)-The Lanett, Ala. sample contained .169 µg/l of Chlordane (tech).
All samples gave negative results for aldrin, heptachlor, heptachlor epoxide, parathion, methyl parathion, fenthion, ethion, malathion and trithion.

(--)-Indicates none detected.

Table 3

TOTAL NUMBER OF CHLORINATED PESTICIDE OCCURRENCES

Year	Number of Samples Collected	Number of Samples With Positive Occurrences	Total Number of Positive Occurrences
1964	97	73	130
1965	99	56	120
1966	109	80	177
1967	110	34	56
1968	114	48	63
Totals	529	291	546

Table 4

PESTICIDE OCCURRENCES BY FWPCA REGION

Pesticide	Northeast	Middle Atlantic	Southeast	Ohio Basin	Great Lakes Basin	Missouri Basin	South Central	Southwest	Northwest	Totals
Dieldrin	31	14	28	20	22	25	34	13	12	199
Endrin	4	4	9	2	7	13	19	5	4	67
DDT	6	4	10	9	2	18	18	10	9	86
DDE	2	1	3	1	4	6	4	5	3	29
DDD	10	6	10	4	10	10	10	4	4	68
Aldrin	0	0	0	0	0	0	1	1	0	2
Heptachlor	1	0	1	2	3	4	3	2	0	16
Heptachlor Epoxide	2	2	3	3	7	6	3	2	1	29
Lindane	2	0	2	0	1	2	3	0	0	10
BHC	2	2	3	12	4	3	7	2	0	35
Chlordane	0	1	3	0	0	0	0	1	0	5
Total	60	34	72	53	60	87	102	45	33	546
Samples	53	32	50	41	76	70	86	65	56	529

TABLE 5 — TOP TEN LOCATIONS AT WHICH HIGHEST LEVELS WERE OBSERVED

1964		1965		1966	
DIELDRIN	µg/l		µg/l		µg/l
Savannah: North Augusta, S. C.	0.118	Tombigbee: Columbus, Miss.	0.100	Merrimack: Lowell, Mass.	0.167
Merrimack: Lowell, Mass.	0.071	Merrimack: Lowell, Mass.	0.068	Savannah: North Augusta, S. C.	0.110
Potomac: Great Falls, Md.	0.040	Savannah: North Augusta, S. C.	0.051	Savannah: Port Wentworth, Ga.	0.048
Schuylkill: Philadelphia, Pa.	0.032	Kanawha: Winfield Dam, W. Va.	0.045	Susquehanna: Conowingo, Md.	0.031
Rio Grande: El Paso, Tex.	0.032	Rio Grande: Alamosa, Colo.	0.029	Delaware Bay	0.025
Platte: Plattsmouth, Neb.	0.023	Tennessee: Lenoir City, Tenn.	0.028	Connecticut: Northfield, Mass.	0.017
Connecticut: Northfield, Mass.	0.022	Ohio: Cairo, Ill.	0.028	Connecticut: Endfield Dam, Conn.	0.016
Savannah: Port Wentworth, Ga.	0.020	Mississippi: Dubuque, Iowa	0.024	Schuylkill: Philadelphia, Pa.	0.015
Mississippi: Vicksburg, Miss.	0.017	Missouri: Kansas City, Kan.	0.023	Chattahoochee: Lanett, Ala.	0.015
Mississippi: New Roads, La.	0.016	Savannah: Port Wentworth, Ga.	0.022	Kanawha: Winfield Dam, W. Va.	0.015
ENDRIN					
Potomac: Great Falls, Md.	0.094	Mississippi: West Memphis, Ark.	0.116	Hudson: Narrows, N. Y.	0.069
Rio Grande: El Paso, Tex.	0.067	Atchafalaya: Morgan City, La.	0.019	South Platte: Julesburg, Colo.	0.063
Big Horn: Hardin, Mont.	0.026	Delaware: Trenton, N. J.	0.018	Savannah: Port Wentworth, Ga.	0.031
Mississippi: Vicksburg, Miss.	0.025	Tombigbee: Columbus, Miss.	0.015	St. Joseph: Benton Harbor, Mich.	0.029
Connecticut: Northfield, Mass.	0.025	Clinch: Kingston, Tenn.	0.015	Lake Superior: Duluth, Minn.	0.022
Red (North): Grand Forks, N. D.	0.023	Rio Grande: Alamosa, Colo.	0.014	Savannah: North Augusta, S. C.	0.022
Mississippi: New Roads, La.	0.023	Monongahela: Pittsburgh, Pa.	0.014	Bear: Preston, Idaho	0.019
Yellowstone: Sidney, Mont.	0.021	Tennessee: Lenoir City, Tenn.	0.009	Clearwater: Lewiston, Idaho	0.015
Columbia: Clatskanie, Ore.	0.019	Red (North): Grand Forks, N. D.	0.009	Connecticut: Northfield, Mass.	0.014
Atchafalaya: Morgan City, La.	0.018	Mississippi: Delta, La.	0.008	Mississippi: Delta, La.	0.014
DDT					
Maumee: Toledo, Ohio	0.087	Rio Grande: Alamosa, Colo.	0.149	Brazos: Arcola, Tex.	0.123
Red (North): Grand Forks, N. D.	0.072	San Juan: Shiprock, N. M.	0.125	Rio Grande: El Paso, Tex.	0.046
San Joaquin: Vernalis, Cal.	0.066	Colorado: Page, Ariz.	0.058	Mississippi: Vicksburg, Miss.	0.044
Atchafalaya: Morgan City, La.	0.047	Platte: Plattsmouth, Neb.	0.039	Arkansas: Fort Smith, Ark.	0.042
Mississippi: Vicksburg, Miss.	0.041	Spokane: Post Falls Dam, Idaho	0.037	Potomac: Great Falls, Md.	0.038
Bear: Preston, Idaho	0.034	Red (North): Grand Forks, N. D.	0.034	Mississippi: Delta, La.	0.031
Columbia: Clatskanie, Ore.	0.034	Ohio: Cairo, Ill.	0.023	Missouri: Kansas City, Kan.	0.029
Red (South): Alexandria, La.	0.031	South Platte: Julesburg, Colo.	0.023	Delaware: Trenton, N. J.	0.028
Willamette: Portland, Ore.	0.029	Mississippi: Delta, La.	0.019	Lake Superior: Duluth, Minn.	0.026
Apalachicola: Chattahoochee, Fla.	0.027	Mississippi, Vicksburg, Miss.	0.017	Snake: American Falls, Idaho	0.025

TABLE 5 — TOP TEN LOCATIONS AT WHICH HIGHEST LEVELS WERE OBSERVED
(continued)

1967		1968	
DIELDRIN	ug/l		ug/l
Savannah: North Augusta, S. C.	0.087	Tombigbee: Columbus, Miss.	0.407
Red (North): Grand Forks, N. D.	0.087	Kanawha: Winfield Dam, W. Va.	0.154
Merrimack: Lowell, Mass.	0.066	Savannah: North Augusta, S. C.	0.059
Schuylkill: Philadelphia, Pa.	0.044	Savannah: Port Wentworth, Ga.	0.039
Savannah: Port Wentworth, Ga.	0.039	Schuylkill: Philadelphia, Pa.	0.027
Potomac: Washington, D. C.	0.025	Apalachicola: Chattahoochee, Fla.	0.027
South Platte: Julesburg, Colo.	0.024	Connecticut: Northfield, Mass.	0.022
Brazos: Arcola, Tex.	0.024	Ohio: Cincinnati, Ohio	0.014
Ohio: Evansville, Ind.	0.020	Mississippi: Cape Girardeau, Md.	0.014
Columbia: Clatskanie, Ore.	0.018	Hudson: Poughkeepsie, N. Y.	0.013
ENDRIN			
Kansas: Lawrence, Kan.	0.133	N O N E	
Maumee: Toledo, Ohio	0.086		
DDT			
Beauclair: Lake Apopka, Fla.	0.316	Beauclair: Lake Apopka, Fla.	0.220
Missouri: Kansas City, Kan.	0.066	Mississippi: Vicksburg, Miss.	0.109
Red (North): Grand Forks, N. D.	0.054	Missouri: Yankton, S. D.	0.053
Mississippi: New Orleans, La.	0.019	Monongahela: Pittsburgh, Pa.	0.051
Rio Grande: Brownsville, Tex.	0.018	Rainy: Baudette, Minn.	0.037
Delaware: Trenton, N. J.	0.017	Arkansas: Pendleton Ferry, Ark.	0.037
		Potomac: Washington, D. C.	0.033
		Hudson: Narrows, N. Y.	0.030
		San Joaquin: Vernalis, Cal.	0.030
		Rio Grande: Alamosa, Colo.	0.029

TABLE 5 — TOP TEN LOCATIONS AT WHICH HIGHEST LEVELS WERE OBSERVED
(continued)

1964		1965		1966	
DDE	µg/l		µg/l		µg/l
Maumee: Toledo, Ohio	0.015	San Juan: Shiprock, N. M.	0.009	Brazos: Arcola, Tex.	0.004
Bear: Preston, Idaho	0.011	Detroit: Detroit, Mich.	0.008	San Joaquin: Vernalis, Cal.	0.003
Mississippi: St. Paul, Minn.	0.011	Yellowstone: Sidney, Mont.	0.002	St. Lawrence: Messena, N. Y.	0.002
South Platte: Julesburg, Colo.	0.009	Platte: Plattsmouth, Neb.	P	Columbia: Clatskanie, Ore.	0.001
Delaware: Martins Creek, Pa.	0.008	Rainy: Baudette, Minn.	P	Arkansas: Pendleton Ferry, Ark.	P
Mississippi: West Memphis, Ark.	0.007			Red (South): Alexandria, La.	P
Columbia: Clatskanie, Ore.	0.005			Rio Grande: El Paso, Tex.	P
San Joaquin: Vernalis, Cal.	0.005			Lake Superior: Duluth, Minn.	P
Snake: Payette, Idaho	0.005			Hudson: Poughkeepsie, N. Y.	P
Seven Stations	0.004			Hudson: Narrows, N. Y.	P
DDD					
Shenandoah: Berryville, Va.	0.083	Rio Grande: Brownsville, Tex.	0.026	Connecticut: Endfield Dam, Conn.	0.013
All others	<0.075	Delaware: Trenton, N. J.	0.018	Rio Grande: Brownsville, Tex.	0.013
		Willamette: Portland, Ore.	0.013	St. Joseph; Benton Harbor, Mich.	0.013
		Missouri: Kansas City, Kan.	0.011	Raritan: Perth Amboy, N. J.	0.012
		St. Lawrence: Messena, N. Y.	0.010	Detroit: Grosse Isle, Mich.	0.012
		Platte: Plattsmouth, Neb.	0.010	Potomac: Great Falls, Md.	0.012
		Waikele Stream: Oahu, Hawaii	0.008	Arkansas: Pendleton Ferry, Ark.	0.012
		Red (South): Alexandria, La.	0.008	Chattahoochee: Lanett, Ala.	0.011
		Merrimack: Lowell, Mass.	0 007	Atchafalaya: Morgan City, La.	0.010
		Potomac: Washington, D. C.	0.007	Missouri: Kansas City, Kan.	0.010
BHC					
Delaware: Martins Creek, Pa.	P	Red (North): Grand Forks, N. D.	0.004	Ohio: Cincinnati, Ohio	0.056
Mississippi: West Memphis, Ark.	P	Ohio: Cairo, Ill.	0.002	Hudson: Narrows, N. Y.	0.034
All others	<0.025	Verdigris: Nowata, Okla.	P	Ohio: Addison, Ohio	0.026
		Connecticut: Endfield Dam, Conn.	P	Rio Grande: El Paso, Tex.	0.023
		Monongahela: Pittsburgh, Pa.	P	South Platte: Julesburg, Colo.	0.022
				Trinity: Livingston, Tex.	0.013
				Allegheny: Pittsburgh, Pa.	0.013
				Mississippi: St. Paul, Minn.	0.012
				Mississippi: Vicksburg, Miss.	0.010
				San Joaquin: Vernalis, Cal.	0.008
				Chattahoochee: Lanett, Ala.	0.008
				Arkansas: Ponca City, Okla.	0.008

TABLE 5 — TOP TEN LOCATIONS AT WHICH HIGHEST LEVELS WERE OBSERVED
(continued)

1967		1968	
DDE	ug/l		ug/l
Beauclair: Lake Apopka, Fla.	0.050	Beauclair: Lake Apopka, Fla.	0.041
Rio Grande: Brownsville, Tex.	0.022		
DDD			
Kansas: Lawrence, Kan.	0.840	Beauclair: Lake Apopka, Fla.	0.156
Maumee: Toledo, Ohio	0.270		
Beauclair: Lake Apopka, Fla.	0.231		
Apalachicola: Chattahoochee, Fla.	0.053		
Delaware: Trenton, N. J.	0.036		
Clinch: Kingston, Tenn.	0.032		
Mississippi: New Roads, La.	0.015		
Tombigbee: Columbus, Miss.	P		
Brazos: Arcola, Tex.	P		
BHC			
Ohio: Cincinnati, Ohio	0.013	Ohio: Addison, Ohio	0.112
Ohio: Evansville, Ind.	0.008	Ohio: Evansville, Ind.	0.055
Saginaw: Bay City, Mich.	0.007	Ohio: Cincinnati, Ohio	0.028
Ohio: Addison, Ohio	0.006	Red (North): Grand Forks, N. D.	0.027
Shenandoah: Berryville, Va.	0.002	Chattahoochee: Lanett, Ala.	0.025
Detroit: Detroit, Mich.	0.002	Arkansas: Coolidge, Kan.	0.025
St. Lawrence: Messena, N. Y.	P	Ohio: Cairo, Ill.	0.020
		Oklawaha: Orlando, Fla.	0.015
		Arkansas: Ponca City, Okla.	0.013
		Susquehanna: Sayre, Pa.	0.009

Table 6

MAXIMUM PESTICIDE CONCENTRATION FOUND VS. PERMISSIBLE WATER SUPPLY CRITERIA AND REASONABLE STREAM ALLOWANCE

(µg/l)

Pesticide	Permissible[a] Criteria	Desirable[a] Criteria	Maximum[b] Reasonable Stream Allowance	Maximum Concentration Found
Dieldrin	17	absent	0.25	0.407
Endrin	1	do	0.1	0.133
DDT	42	do	0.5	0.316
DDE	--	--	--	0.050
DDD	--	--	--	0.840
Heptachlor	18	absent	1.0	0.048
Heptachlor Epoxide	18	do	1.0	0.067
Aldrin	17	do	0.25	0.085
Lindane (BHC)	56	do	5.0	0.112
Chlordane	3	do	0.25	0.169
Methoxychlor	35	do	20.0	(c)
Toxaphene	5	do	2.5	(d)
Organophosphates plus Carbamates	100	do	--	0.380
Herbicides: 2,4-D plus 2,4,5-T plus 2,4,5-TP	100	do	--	(c)
Phenols	1	do	--	(c)

(a) From the "Report of the Committee on Water Quality Criteria" (6)

(b) Suggested by Ettinger and Mount (7)

(c) Not determined

(d) Not detected

(--) Not given for these compounds

Table 7

LOCATIONS WITH HIGH FREQUENCY OF PESTICIDE OCCURRENCE

(at least one pesticide found in each survey)

River	Location
Merrimack	Lowell, Mass.
Delaware	Trenton, N. J.
Delaware	Martins Creek, Pa.
Schuylkill	Philadelphia, Pa.
Potomac	Great Falls, Md.
Apalachicola	Chattahoochee, Fla.
Chattahoochee	Lanett, Ala.
Savannah	Port Wentworth, Ga.
Savannah	North Augusta, S. C.
Ohio	Evansville, Ind.
Ohio	Cincinnati, Ohio
Kansas	Lawrence, Kan.

Table 8

LOCATIONS WITH LOW FREQUENCY OF PESTICIDE OCCURRENCE

River	Location	Surveys	Occurrences
Connecticut	Wilder, Vt.	5	1
Raritan	Perth Amboy, N. J.	3	1
Lake Erie	Buffalo, N. Y.	5	1
St. Clair	Port Huron, Mich.	4	0
Rainy	International Falls, Minn.	3	0
Colorado	Parker Dam, Ariz.-Cal.	5	0
Colorado	Boulder City, Nev.	5	1
Truckee	Farad, Cal.-Nev.	5	0
Green	Dutch John, Utah	5	0
Snake	American Falls, Utah	3	1
Pend Oreille	Albeni Falls, Idaho	5	0
Klamath	Keno, Ore.	5	1
Columbia	McNary Dam, Ore.	5	0
Columbia	Pasco, Wash.	5	1
Columbia	Bonneville, Ore.	3	1